Fukushima & Three Mile Island Events: Advancing Nuclear Safety

HOUSE COMMITTEE ON SCIENCE, SPACE AND TECHNOLOGY:
SUBCOMMITTEES ON INVESTIGATIONS AND OVERSIGHT AND ENERGY AND ENVIRONMENT
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Disclaimer: Fukushima Information is preliminary especially regarding interpretation of events; opinions expressed are mine and mine alone.

Fukushima Daiichi Nuclear Power Station

Event Initiation

March 11, 2011

•About 14:46, a 9.0 magnitude earthquake struck (Plant design basis earthquake: 8.2)- **Plant safety systems reportedly function satisfactorily.**

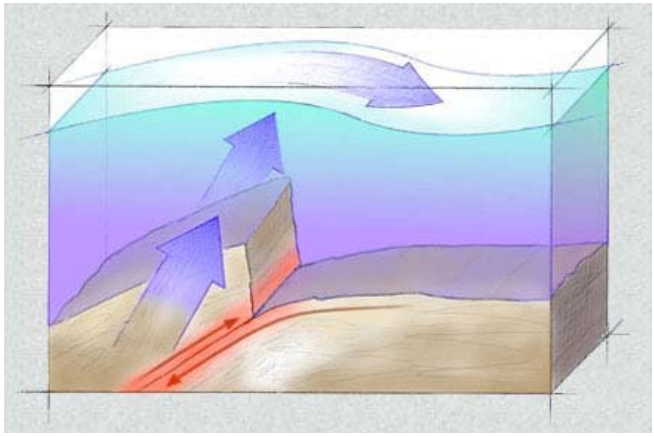
•Units 1,2 & 3 Scram & Unit 4 has 100 day old core offloaded into Unit 4 Spent Fuel Pool

•~ 15:45, a tsunami 14 meters high inundated the site, whose design basis was 5.7 meters – the reactors and backup diesel power sit roughly 10 to 13 meters above sea level

•The impacts up and down the northeast coast resulted in tragic loss of 20,000+ lives, damage, and destruction of infrastructure.

By Janet Loehrke, USA TODAY

Subduction Fault

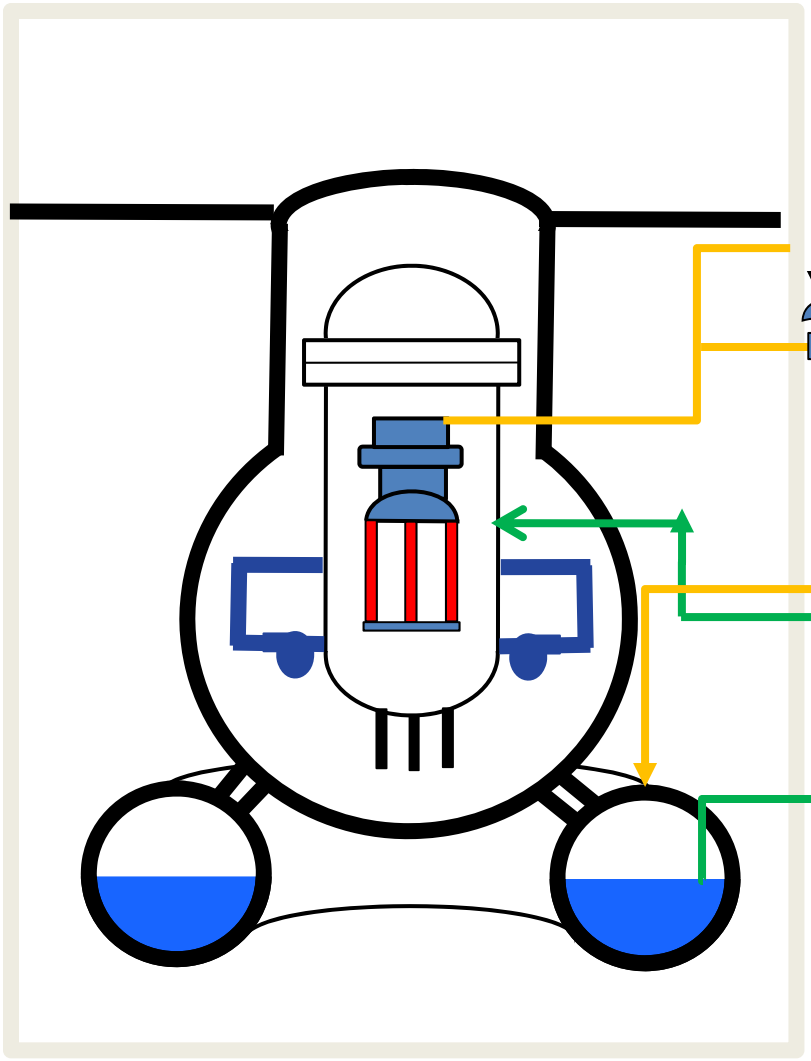


Tsunami Waves

Tsunami Size: Main Safety Factor

3/11 15:45

Battery Power Control of Steam-Driven Reactor Core Isolation Cooling System In Units 2 &3 (Unit 1 Had Isolation Condenser which Boiled Dry)

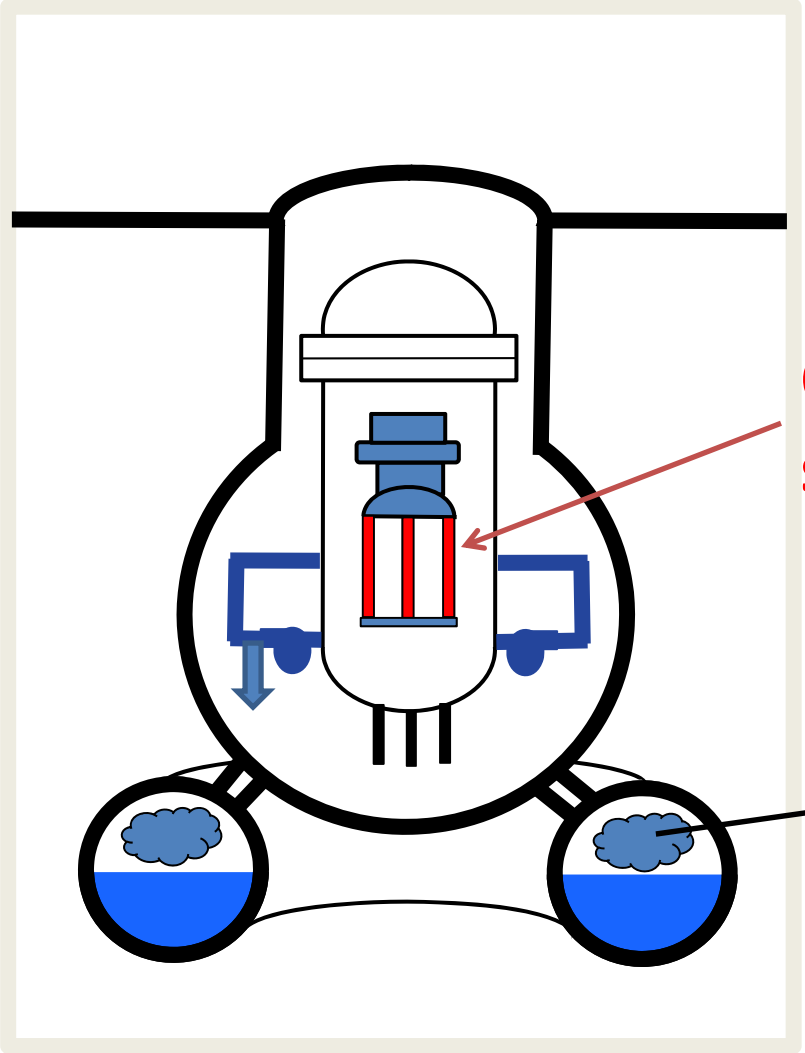


3/11 15:45 JST

CST?

3/11 15:45 to ~ 3/11 24:00 JST

Battery Power Exhausted

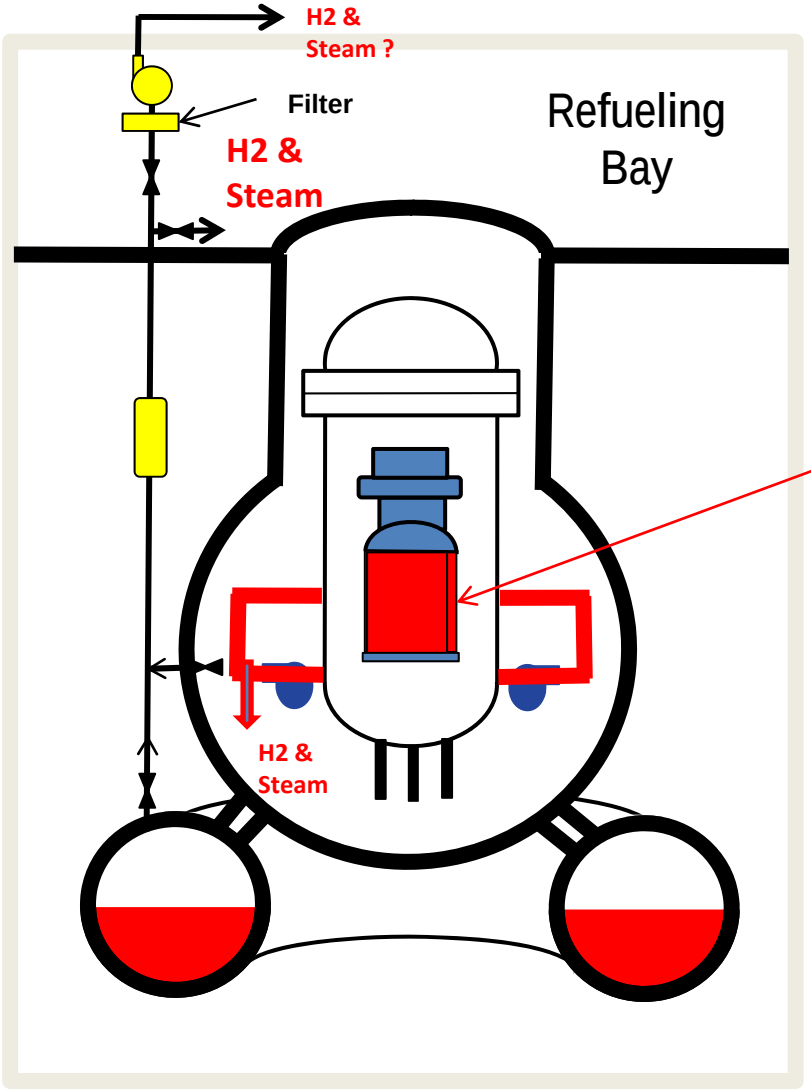


Core Uncovers and starts to overheat

Suppression pool (wet well) becomes saturated

3/12 ~02:00 JST

Venting Primary Containment



Core Overheated
Fuel Cladding Oxidizes
Hydrogen Generated

Primary Containment Pressure
~ 90psia @02:00 3/12

3/12 ~05:30 U1
3/13 ~ 00:00 U2
3/13 ~ 08:40 U3

Unit 1 Reactor Building Explosion

3/12 15:31

Unit 3 Reactor Building Explosion

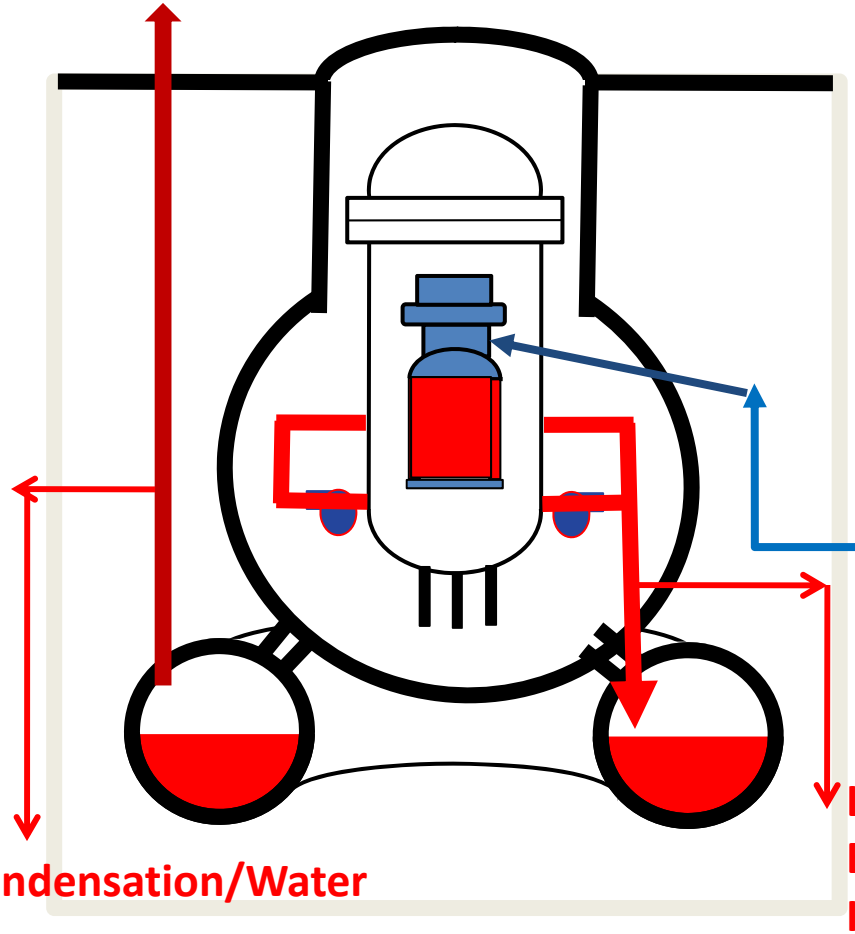
3/14 11:15

Bleed & Feed Core Cooling Established

Seawater Injection Started Using Fire Engine Pump

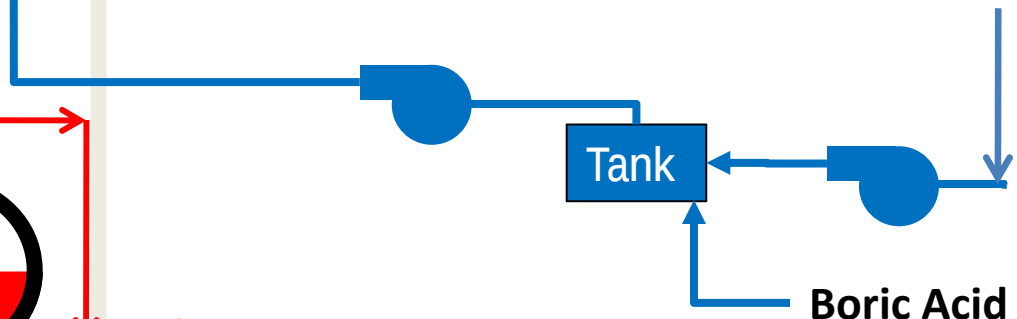
Shift to Fresh Water Injection: To Dissolve Possible Salt Cakes

Vapor Venting



Water Core Injection

Seawater	Fresh	Rate (gpm)
U1 3/12 20:20	3/25	25-60 (Fill DW)
U3 3/13 13:10	3/25	30
U2 3/14 16:30	3/26	30



Condensation/Water

Leakage to Reactor Building-Turbine Bldg-Intake Structure

Water Spray to Unit 3 Pool Area

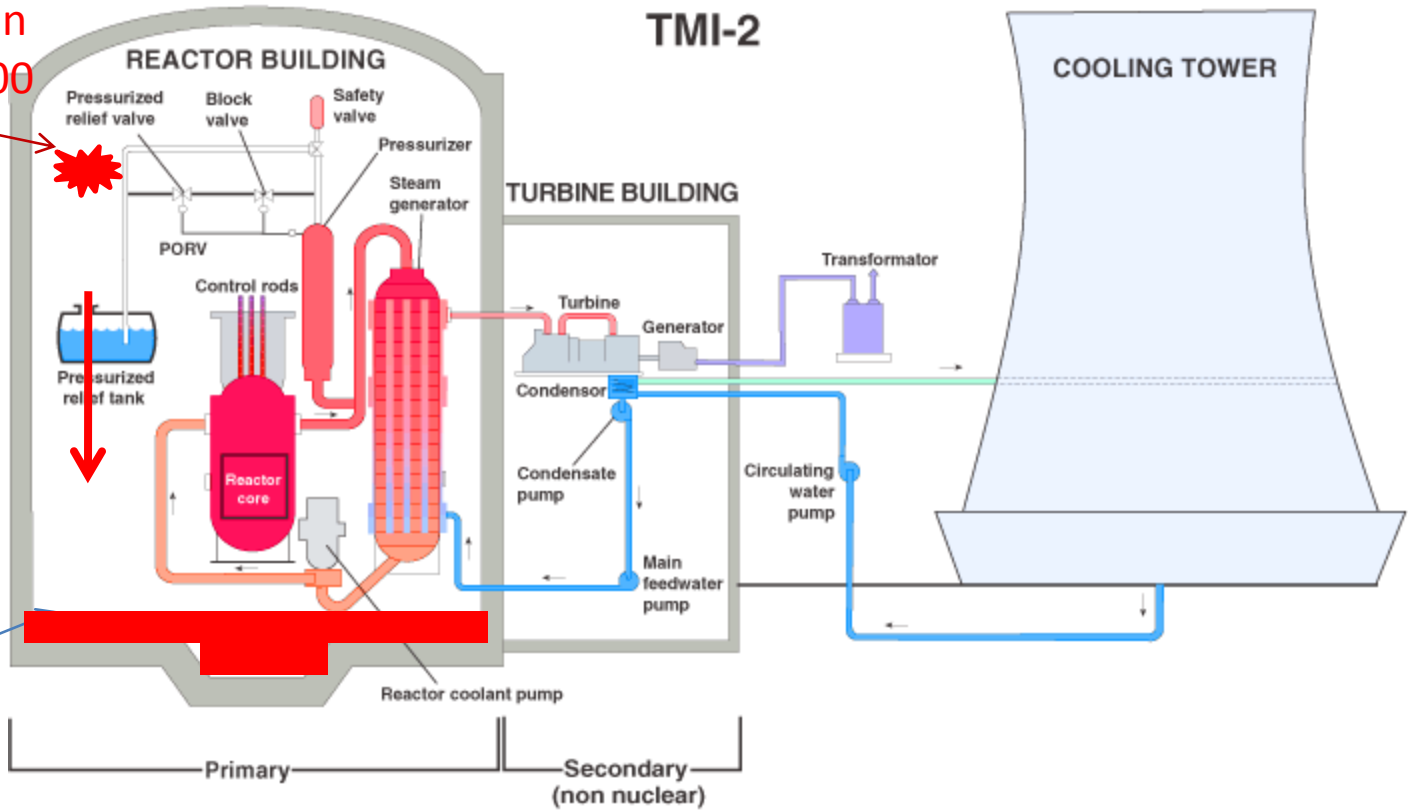
Unit 4 Reactor Building
Water Injection Boom To Spent Fuel Pool

Three Mile Island Units 1 &2

March 28, 1979

Three Mile Island
March 28, 1979

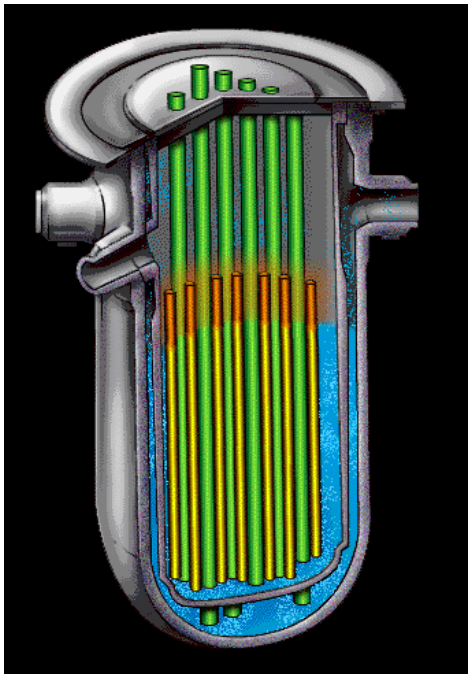
Hydrogen Deflagration 28psig 13:00

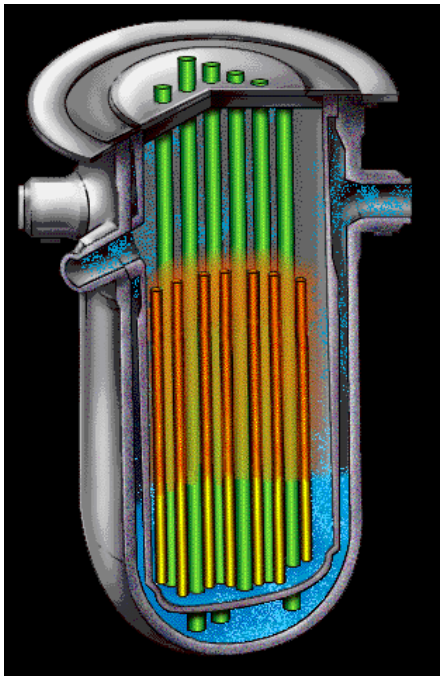


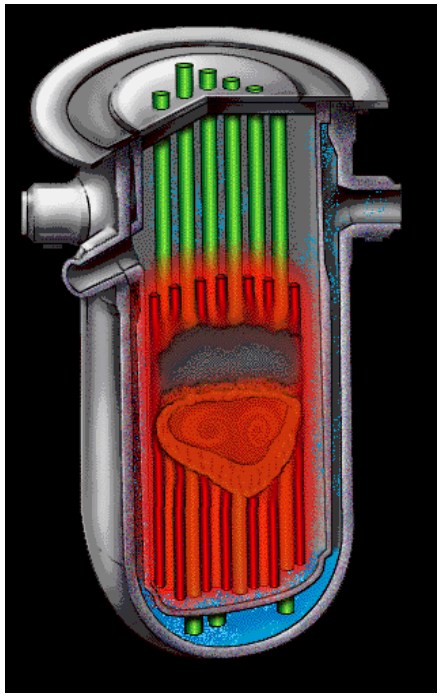
~3M deep water ~1000R/hr

Precautionary 5 Mile Evacuation Issued

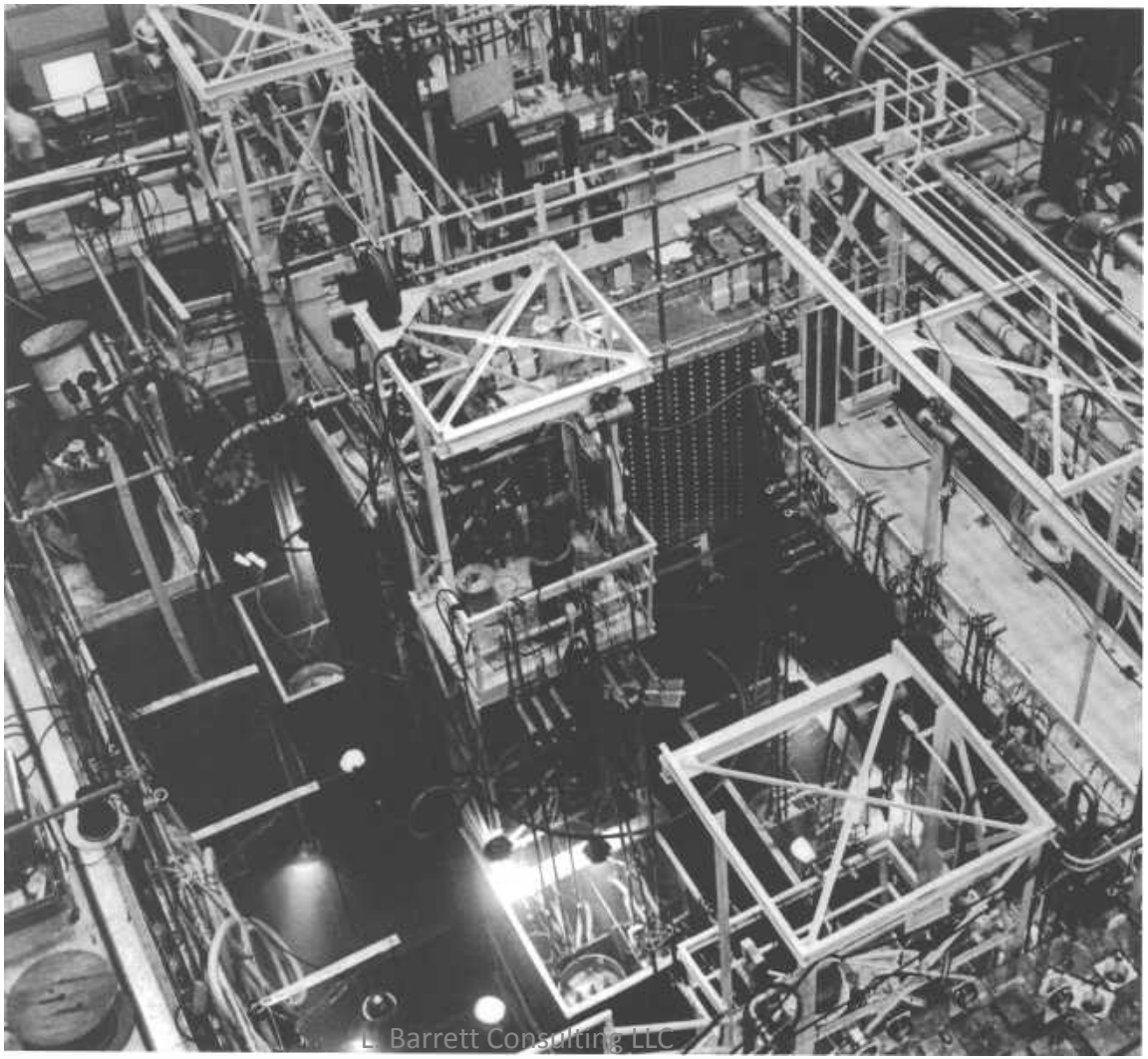
TMI Core Damage Sequence







High Rad Reactor Water Cleanup System Installed in Spent Fuel Pool



TMI Damaged Core Removal

~1985-1990

Three Mile Island History

- Reactor Scram: 04:00 3/28/79
- Core melt and relocation: ~ 05:00 – 07:30 3/28/79
- Hydrogen Deflagration: 13:00 3/28/79
- Recirculation Cooling: Late 3/28/79
- Phased Water Processing: 1979-1993:Removed ~1.2MCi Cs137
- Containment Venting 43KCi Kr-85: July 1980
- Containment Entry: July 1980
- Reactor Head removed and core melt found: July 1984
- Start Defuel: October 1985
- Shipping Spent Fuel: 1988-1990
- Finish Defuel: Jan 1990
- Evaporate ~2.8M gallons Processed Water: 1991-93
- Cost: ~$1 Billion

Fukushima Stabilizing

- Working to Establish Recirculation Core Cooling
- Mitigate Airborne Releases
- Mitigate Water Releases
- Gain Building Access to Start Recovery Activities
- Maintain Personnel Safety: High Rad Areas
- Reduce and Mitigate Evacuation Zone Impacts

Units 1-4 After U4 Spent Fuel Pool Explosion
3/16

Unit 3 & Unit 4

Soil/Dust Suppression Resin Application

Contaminated Water Containment

Overflow from U2 Reactor Bldg to Turbine Bldg to Intake Structure Wall Crack to Sea

~130KCi Released this Path

~Total Site Cs137(to 4/12) Released 300KCi

-Reference Chernobyl was 2MCi Cs-137 released

Non-Safety Grade intake Structure

Radioactive Water Leak 11-04-02

Leak Reduced 11-04-04

Leak Sealed 11-04-06
Sodium Silicate Injection

Decontamination-Cleanup

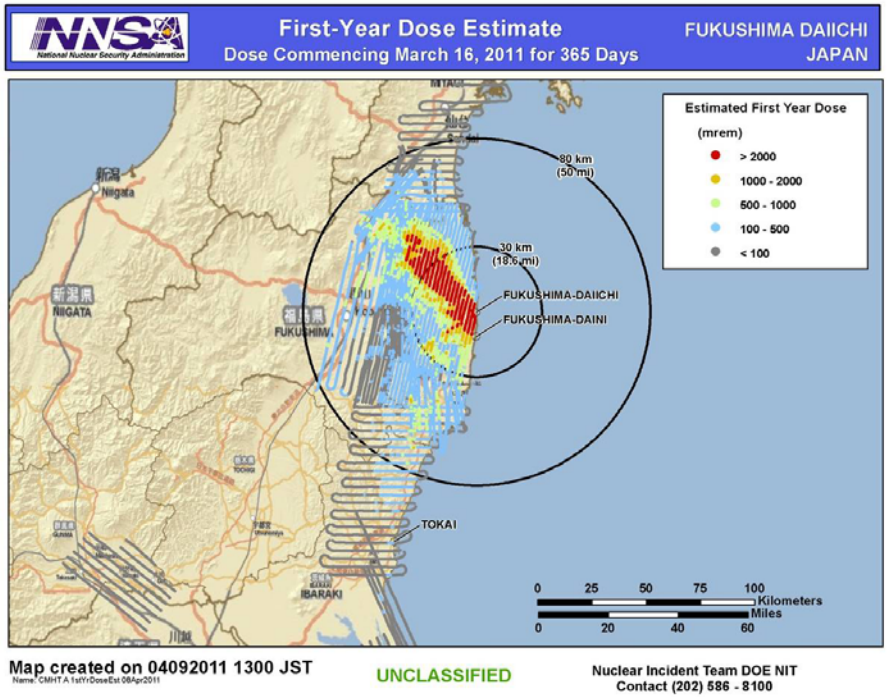
High Radiation Field Work with Remotely Operated Equipment

Remote Equipment Operator

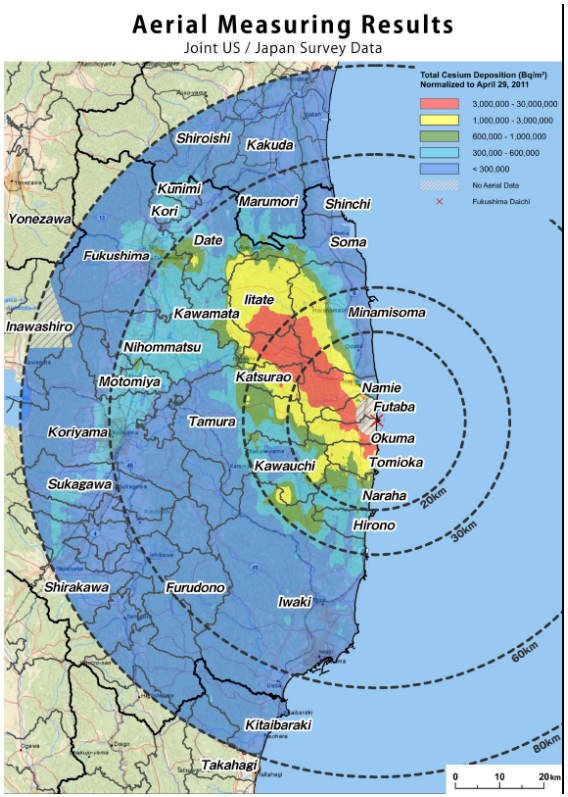
Remotely Operated Construction Equipment Reducing Gamma Field and Debris Removal

Offsite Impacts

Future Institutional Challenges But Minimal Health Impact



Dose Impact Projections



Cesium Ground Deposition
~ Ten+ KCi Cs Deposition

Personal Fukushima Observations

- **Not a Public Health Catastrophe**
  - **Nuclear Impacts Inconsequential Compared to Earthquake/Tsunami Impacts**
- **Is An Industrial Plant Catastrophe**
  - **The tsunami was the Main Safety Issue**
  - **Three Severely Damaged Cores and Some Damaged Spent Fuel Pool inventories**
  - **Units 1-4 Complete Loss, Units 5 &6 Technically Recoverable**
  - **Cleanup Long & Expensive, but Technically Achievable (Much Larger than TMI)**
- **Energy Dissipation is Getting Better, but Challenging**
  - **Aftershock Safety**
- **Environmental Release Mitigation is a Growing Challenge**
  - **Continued Feed & Bleed Vapor/Water Radioactive Effluents**
  - **Environmental Mitigation, Social, Political & Economic Issues**
  - **Institutionally Challenging Infrastructure Issues Ahead**

Personal U.S. Nuclear Safety Observations

- **Current Reactors Have Adequate Safety Margins**
  - **U.S. Tsunami Risks are Limited To Only A Few U.S. Sites**
- **Past Risk Informed Severe Accident Improvements Have Already Addressed Many Fukushima Issues**
    - **Station Blackout & 911 Improvements**
- **Systematic, Methodical, & Risk Informed Fukushima Lessons Learned Evaluations Are Appropriate**
  - **Industry**
  - **NRC**
  - **Resist "Quick Fix" Emotional Reactions**
  - **Continuous Improvement Culture Will Further Strengthen U.S. Capabilities**
- **Lessons Learned From TMI Lessons Learned**
  - **TMI Lessons Learned Greatly Improved US Nuclear Safety and Productivity**
  - **Most Painful Lessons are the Most Teachable**
  - **Fukushima Lessons Should Improve Safety and Advance Global & U.S. Nuclear Energy As Three Mile Island Lessons Learned Did Thirty Years Ago.**